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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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10/649,351

08/26/2003

Sang-Hyeob Lee

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07/14/2005

BEYER WEAVER & THOMAS LLP

P.O. BOX 70250

OAKLAND, CA 94612-0250

EXAMINER

NGUYEN, HA T

ART UNIT

PAPER NUMBER

2812

DATE MAILED: 07/14/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

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<b>Office Action Summary</b>	<b>Application No.</b> 10/649,351	<b>Applicant(s)</b> LEE ET AL.	
	<b>Examiner</b> Ha T. Nguyen	<b>Art Unit</b> 2812	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --  
**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

- 1) ☒ Responsive to communication(s) filed on 22 April 2005.  
 2a) ☒ This action is **FINAL**.                      2b) ☐ This action is non-final.  
 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims**

- 4) ☒ Claim(s) 1-13 and 15-35 is/are pending in the application.  
     4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.  
 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.  
 6) ☒ Claim(s) 1-13 and 15-35 is/are rejected.  
 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.  
 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

**Application Papers**

- 9) ☐ The specification is objected to by the Examiner.  
 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
     Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
     Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).  
 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

**Priority under 35 U.S.C. § 119**

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).  
     a) ☐ All    b) ☐ Some \*    c) ☐ None of:  
         1. ☐ Certified copies of the priority documents have been received.  
         2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.  
         3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).  
     \* See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)  | 4) <input type="checkbox"/> Interview Summary (PTO-413)<br>Paper No(s)/Mail Date. _____ |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948)   | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152)             |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)<br>Paper No(s)/Mail Date <u>4-14&amp;28-5</u> . | 6) <input type="checkbox"/> Other: _____  |

## DETAILED ACTION

### *Notice to applicant*

1. Applicant's Amendment and Response to the Office Action mailed 02-08-05 has been entered and made of record.

### *Claim Rejections - 35 USC § 103*

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claims 9-13 and 19-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang et al. (USPN 5028565, hereinafter "Chang") in view of Klaus et al.'s "Atomically controlled growth of tungsten and tungsten nitride using sequential surface reactions" (hereinafter "Klaus").

Referring to the Fig. and related text, Chang discloses [Re claims 9-10 and 13] a method of forming a tungsten nucleation layer on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate by contacting the semiconductor substrate with tungsten-containing gas and a reducing agent in the presence of nitrogen; and (b) depositing a tungsten bulk layer on the tungsten nucleation layer by a CVD process in which the semiconductor substrate is exposed to nitrogen; wherein (b) comprises exposing the semiconductor substrate to a tungsten-containing gas selected from the group consisting of WF<sub>6</sub> and W(CO)<sub>6</sub> and combinations thereof (See col. 4, line 49-col. 5, line 68). But it fails to disclose expressly the use of alternating pulses of reactant gases; wherein (a) comprises performing PNL by alternating exposure of the semiconductor substrate to the tungsten-containing gas and the reducing agent; wherein (a) comprises delaying exposure of the semiconductor substrate to nitrogen until after deposition of the tungsten nucleation layer has begun. However, the missing limitations are well known

in the art because Klaus discloses these features (See pages 480 left col., 482, and 485, right col.), the examiner interpreted that the substrate is exposed to N<sub>2</sub> is delayed because the deposition of the tungsten nucleation has begun with the first exposure to WF<sub>6</sub> in the first cycle. A person of ordinary skill is motivated to modify Chang with Klaus to obtain smooth nucleation layer with low impurity (see Abstract).

[Re claims 11-12] Chang also discloses wherein the nitrogen employed in (a) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate and wherein the nitrogen employed in (b) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate (see col. 5, lines 8-19).

[Re claims 19-24, 26-27, 29-32 and 35] The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate in a reaction chamber, the method comprising: (a) forming a reducing layer on the semiconductor substrate; (b) contacting the reducing layer with a tungsten-containing gas to thereby reduce the tungsten-containing gas to a tungsten layer on the semiconductor substrate; (c) contacting the semiconductor substrate with a reducing agent to form a layer of reducing agent; and (d) contacting the layer of reducing agent with the tungsten-containing gas to thereby reduce the tungsten-containing gas to another tungsten layer on the semiconductor substrate; heating the semiconductor substrate to a temperature of between about 200 and 400°C and contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the vapor phase comprises a nitrogen carrier gas in addition to the borane compound; purging the reaction chamber of the reducing compound after contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the tungsten-containing gas of (b) and (d) has the same composition; wherein the tungsten-containing gas of (b) comprises WF<sub>6</sub>; wherein the layer of reducing agent formed in (c) is a self-limiting layer; wherein the layer of reducing agent formed in (c) is a silane; repeating (c) and (d) for at least one cycle; exposing the semiconductor substrate to a pulse of WF<sub>6</sub> prior to (a), as shown above. But it does not disclose that the reducing agent is a borane compound, diborane. However, the examiner takes Official Notice, it is well known in the art that diborane and silane are equivalently used as reducing agent.

[Re claims 25, 28, and 33-34] The combined teaching of Klaus and Chang does not disclose expressly the claimed duration of exposure to reactants and wherein the duration of contacting with the tungsten-containing gas in an earlier cycle is shorter than the duration of contacting with the tungsten-

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containing gas in a later cycle; and wherein the duration of contacting with the tungsten-containing gas in (b) is shorter than the duration of contacting with the tungsten-containing gas in (d). However, it would have been obvious to an ordinary artisan to do so to obtain an appropriate amount of reactants for each cycle and to prevent corrosion of underlying layer from HF, a reaction product.

Therefore, it would have been obvious to combine Chang with Klaus to obtain the invention as specified in claims 9-13 and 19-35.

4. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang in view of Klaus and Sukharev et al. (USPN 5804249, hereinafter "Sukharev").

The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate; (b) depositing a tungsten bulk layer on the nucleation layer using a chemical vapor deposition (CVD) process; wherein (a) comprises: positioning the semiconductor substrate in a reaction chamber; heating the semiconductor substrate; and performing PNL on the semiconductor substrate using a tungsten-containing gas and a reducing gas; wherein the reducing agent is a silane; wherein (b) comprises exposing the semiconductor substrate to a process gas comprising one or more of the following: WF<sub>6</sub>-H<sub>2</sub>, WF<sub>6</sub>-B<sub>2</sub>H<sub>6</sub>, and W(CO)<sub>6</sub>; wherein the PNL comprises: (i) flowing a reducing gas into a deposition chamber holding the semiconductor substrate, whereby the reducing gas is adsorbed onto said semiconductor substrate; (ii) purging the reducing gas from the deposition chamber; (iii) flowing a tungsten-containing gas into said deposition chamber, whereby said deposited reducing gas is substantially reduced to a tungsten film; (iv) purging the tungsten-containing gas from the deposition chamber; and (v) repeating (i) through (iv) for one or more additional cycles; wherein the reducing gas is a silane, as shown above.

But it fails to disclose expressly (c) depositing a tungsten cap layer on the tungsten bulk layer using a pulsed nucleation layer (PNL) deposition technique; and repeating (b) and (c) many times.

However, the missing limitations are well known in the art because Sukharev discloses depositing more than one bulk layer and repeat the deposition of bulk layers many times (See Summary).

A person of ordinary skill is motivated to modify Klaus and Chang with Sukharev to appropriately adjust the deposition of W layers and optimize the smoothness of the W layers ensuring thickness uniformity.

Therefore, it would have been obvious to combine Klaus and Chang with Sukharev to obtain the invention as specified in claims 1-8 .

5. Claims 15-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang in view of Klaus, as applied above, and further in view of Berenbaum et al. (USPN 6066366, hereinafter "Berenbaum").

The combined teaching of Chang and Klaus discloses substantially the limitations of claims 14-18, as shown above.

But it fails to disclose expressly the timing of the nitrogen exposure.

However, the missing limitation is well known in the art because Berenbaum discloses this feature (See col. 5, line 31-col. 6, line 25 and Fig. 1).

A person of ordinary skill is motivated to modify Chang and Klaus with Berenbaum to optimize the use of nitrogen in the deposition of W.

Therefore, it would have been obvious to combine Chang and Klaus with Berenbaum to obtain the invention as specified in claims 15-18.

### ***Response to Amendment***

6. Applicants' arguments with regard to the rejections under 35 U.S.C. 102 or 103 have been fully considered, but they are not deemed to be persuasive for at least the following reasons.

Applicants argued that diborane and silane are not equivalently used as reducing agents. The examiner disagreed Elers et al. (WO 01/273447, page 4, lines 18-21) and Takagi et al. (USPN 6107200, col. 1) are cited to show the widespread use of diborane and silane as reducing agents.

Applicants also argued that Klaus discloses a conventional ALD process with self-limiting characteristics, which is different from the claimed invention. The examiner disagreed, Klaus read on the rejected claims because the claims do not preclude the self-limiting cyclic deposition.

Applicants argued that the Sukharev does not teach a W stack terminated by a cap layer. The examiner disagreed. Sukharev discloses the deposition of an amorphous W layer followed by a bulk W

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layers and the repeated deposition of these two layers (see par. bridging cols. 7-8). Depending on the size of the opening either the amorphous layer or the bulk layer can be the last layer deposited, therefore in some opening the amorphous layer would terminate the stack.

Therefore the applied references do teach or make obvious all the limitations of the rejected claims.

### ***Conclusion***

7. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for response to this final action is set to expire THREE MONTHS from the date of this action. In the event a first response is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event will the statutory period for response expire later than SIX MONTHS from the date of this final action.

8. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ha T. Nguyen whose telephone number is (571) 272-1678. The examiner can normally be reached on Monday-Friday from 8:30AM to 6:00PM, except the first Friday of each bi-week. The telephone number for Wednesday is (703) 560-0528.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael S. Lebentritt, can be reached on (571) 272-1873. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the

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Ha Nguyen  
Primary Examiner  
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